OPERATIONAL AND LABORATORY CAPABILITIES

OF

"JOIDES RESOLUTION"

OCEAN DRILLING PROGRAM
TEXAS A&M UNIVERSITY

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Philip D. Rabinowitz
Director

Louis E. Garrison
Deputy Director

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I. INTRODUCTION

This publication introduces the Ocean Drilling Program's (ODP) drillship JOIDES Resolution and her capabilities to the scientific community.

One of ODP's principal tasks in the start-up period was to procure a drilling vessel, and, after much deliberation (including consideration of a Glomar Challenger conversion), SEDCO/BP 471 was selected (Figure 1). This vessel, now also called JOIDES Resolution, was originally built as a joint venture between SEDCO and British Petroleum. It was designed by Earl and Wright and assembled in Halifax, Nova Scotia, Canada, in 1978 by Hawker Siddeley (Canada), Ltd. The ship is 470 ft (143 m) long, 70 ft (21 m) wide and has a displacement of 16,596 long tons. The derrick towers 202 ft (61.5 m) above the waterline.

Before sailing for ODP, the ship was one of the most modern dynamically positioned drillships serving the oil industry. Her first assignment was a unique project to bury a pipeline in the North Sea. The ship hovered over a high-pressure gas line running from the middle of the North Sea to Germany and covered the exposed line with gravel. This was the first time an operation of this kind had been successfully attempted. Immediately afterward, the vessel drilled several wells offshore Brazil in water depths from 1000 ft (305 m) to 2000 ft (610 m). After completing this project, the ship moved to the Ivory Coast offshore West Africa and drilled several wells in water depths of 1000 ft (305 m) to 3000 ft (915 m). In the summer of 1982, the ship moved to the Gulf of Mexico to drill in deep water and, in 1983, drilled a well in the record water depth to that date, 3500 ft (1067 m). The ship then moved to Pascagoula, Mississippi, for conversion prior to joining the Ocean Drilling Program.

A three-story prefabricated laboratory structure has been installed on the starboard side of the main deck (Figure 2) and connects to the below-deck spaces by a stairway and an elevator. By taking over part of the casing hold, three levels of the lab stack have been accommodated below deck. A downhole logging laboratory overlooking the rig floor is situated atop the lab structure. An underway geophysics lab is located on the fantail under the helicopter deck. JOIDES Resolution now offers:

(1) a 30,000-ft (9150 m) drill string,

(2) a stable drilling platform,

(3) a large below-deck storage area for drill pipe and casing,

(4) a draw works with 31,000 ft (9450 m) of wireline,

(5) berths for up to 50 scientific and technical personnel and 65 drilling crew,

(6) 12,000 sq ft (1115 sq m) of laboratory and office space, and

(7) a strengthened hull for drilling in high-latitude waters.

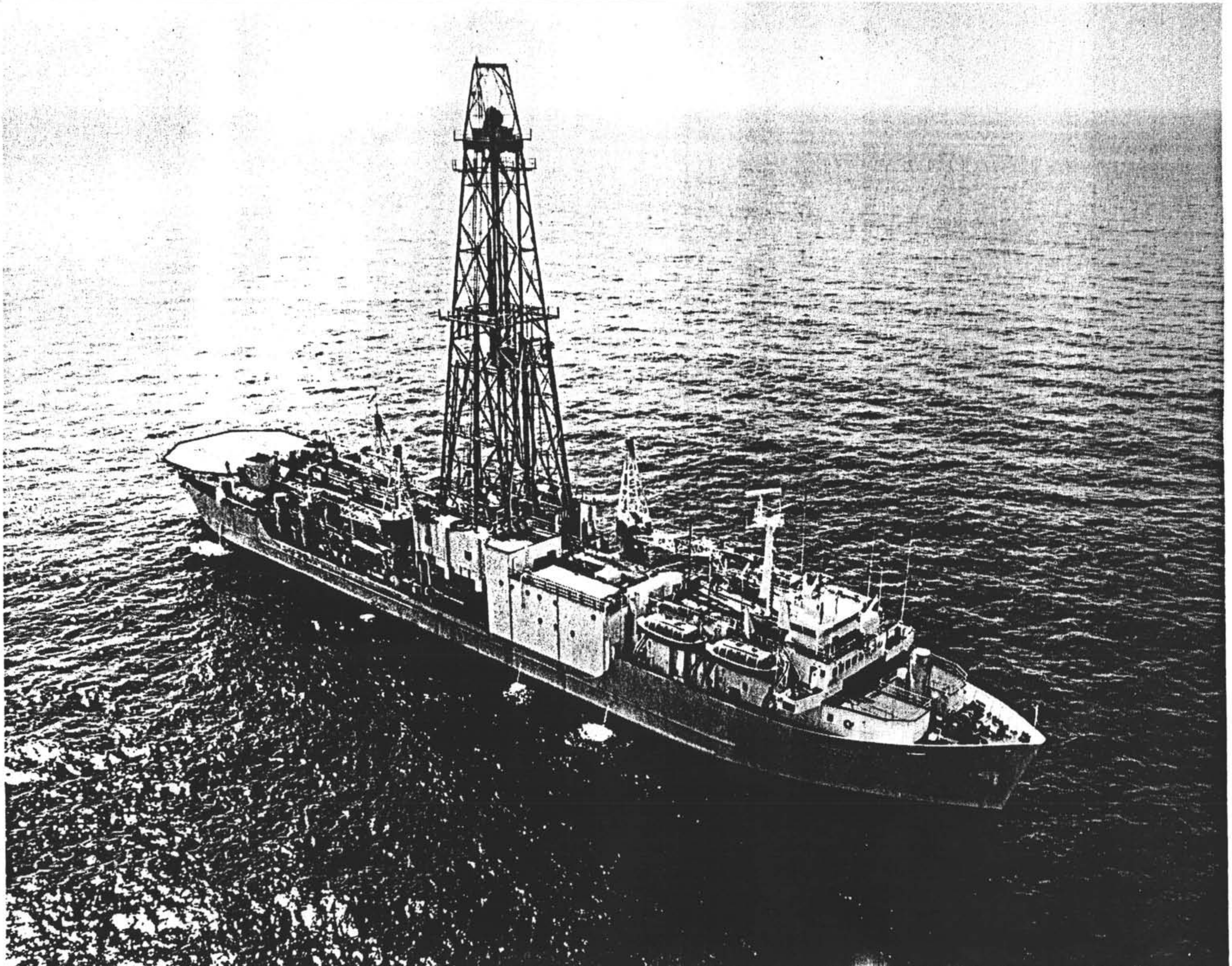


Figure 1

The following sections describe the ship's drilling capabilities and laboratory facilities that make her the most comprehensive and up-to-date research vessel afloat.

II. OPERATIONAL CAPABILITIES

The capabilities of Glomar Challenger, retired in 1983 after fifteen years with the Deep Sea Drilling Project (DSDP), and ODP's JOIDES Resolution are compared in the accompanying Table 1. The primary advantages of the new vessel include increased available power, better drilling depth capabilities, and more berthing, laboratory, and storage space. These and other less apparent factors are discussed below.

Available Power

The diesel-electric power available for cruising, positioning, and general use is 14,700 kilowatts. Although the large sail and luff area and turning moment of the ship mean more power must be available to the thrusters and main shafts for positioning, this is offset by a positive, accurate Honeywell dynamic positioning system. The enormous power and new dynamic positioning system together should save time in initial positioning and re-entry maneuvers, ensure increased safety to the drill string, and significantly increase the capability of operating in adverse environmental conditions.

Greater shaft horsepower means an average transit speed of about 12-13 knots, lengthening the time available for suspended-pipe operations. A review of the final twelve DSDP legs shows that approximately 3,350 nautical miles were traveled per voyage. The ODP track planned for 1985-86 indicates no significant reduction in transit distance. An increase of two knots in average speed will result in an additional 17 days of operating time per year.

Power distribution is through a modern silicon-control rectifier (SCR) system. This means that electrical power is taken from a common AC bus and used as needed. The ship's computerized power management system can automatically start or secure an engine as load conditions warrant, or shed nonessential loads to prevent an overload on critical circuits.

Power throughout the laboratory stack is either 120V or 208V, 3-phase, 60 cycle. Circuits are available in each lab for both ship's power and regulated power. Regulated power by definition is not uninterruptible power, but power in which the output voltage is kept within certain limits and voltage spikes are truncated.

Drilling Capabilities

Efficiency in the drilling operation results from several factors. A 400-ton (400,000-kg) in-line heave compensator provides dependable weight compensation for coring operations and downhole experiments, increases bit life, and streamlines drilling operations since no time is spent in picking up or setting back the compensator. A new electric top drive features a wider rotary speed range and higher torque than the hydraulic power sub.

TABLE 1

COMPARISONS BETWEEN GLOMAR CHALLENGER AND JOIDES RESOLUTION (SEDCO/BP 471)

	GLOMAR CHALLENGER	SEDCO/BP 471
Construction completed	March 1968	January 1978
Length x Beam	400 ft x 65 ft	470 ft x 70 ft
Draft	21 ft	24 ft
Displacement	10,600 T	16,700 T
Derrick Height (above water)	196 ft	202 ft
Average Speed	9 kt	11+ kt
Available shaft HP under way	4,500 HP	9,000 HP
Thrusters	Four: 750 HP	Twelve: 800 HP
Maximum Complement	74	116
Scientific Complement	29	50
Scientific Space	4,500 sq ft	12,700 sq ft
Working Drill String	5" to 23,000 ft	5-1/2" and 5" to 30,000 ft
Practical Water Depth Limit	21,000 ft	27,000 ft
Re-entry Water Depth Limit	18,000 ft	20,000 ft
Derrick Capacity	500 T	600 T
Heave Compensator	294 T, Brown Bros. Single Cyl, suspended	400 T, Western Gear Twin Cyl, in-line
Rotary Top Drive	Bowen Hydraulic	Varco Electric
Maximum Sandline Length	26,000 ft	31,000 ft
Cranes	One 50 T, One 15 T	Two 60 T, One 30 T
Dry Bulk Mud/Cement Storage	12,300 cu ft	13,300 cu ft
Liquid Mud Storage	2,480 bbl	3,825 bbl
Fuel Storage	16,735 bbl	21,288 bbl
Drill Water Storage	5,550 bbl	13,000 bbl
Potable/Wash Water Storage	4,517 bbl	1,001 bbl
Fresh Water Distilling Cap.	300 bbl/day	695 bbl/day

The ability to optimize RPM (revolutions per minute) should increase bit life and penetration rate. With greater penetration per bit, the number of time-consuming re-entries should be reduced. Pipe-handling safety and efficiency is upgraded through the use of an "iron roughneck," which eliminates using cumbersome suspended tongs from most phases of the operation.

The unobstructed 22-ft (7-m) diameter moonpool of JOIDES Resolution and a redesigned re-entry cone make it possible to deploy cones through the moonpool.

A new electric-hydraulic logging winch provides efficient, quiet, and almost maintenance-free performance. It has a 31,000-ft (9450-m) cable.

In the future, the ship can be converted to deploy a marine riser for continental margin drilling where a circulating mud system is required.

Navigation

JOIDES Resolution is equipped with all basic navigational systems including satellite navigation and LORAN C. The addition of Global Positioning System (GPS) capability during 1985 will be a significant improvement to JOIDES Resolution's navigational capabilities.

Communication

A state-of-the-art satellite communications system offers direct telephone, TELEX, facsimile, direct data transmission, and electronic mail capabilities from most operating areas to ODP headquarters in College Station without regard to atmospheric conditions and communications "windows." Continuous wave and limited single-side band capabilities are also available on JOIDES Resolution for operating in areas outside satellite communications coverage or as a backup in the event of irreparable equipment failure. These methods of communication, however, require the assistance of a shorebased radio station.

Cruising Range

For normal drilling operations JOIDES Resolution can remain at sea for about 120 days and carry more than one million gallons of fuel. The cruising range is dependent, of course, on underway speed and the ratio of onsite to underway time.

Ice/Cold Weather Operation

JOIDES Resolution's hull is rated ABS Ice Class 1B for "navigation in medium ice conditions." This is believed to be the highest ice classification of any drillship currently in service. It increases in-transit safety to and from high-latitude operating areas. As with Glomar Challenger, no plans have been made for site operations in areas where there is an immediate threat of contact with icebergs or pack ice.

The ship was designed and constructed for work in cold-weather localities, and most work areas are enclosed and/or warmed with a hot water heating system.

Stability and Vessel Motion

Due to its size and displacement, JOIDES Resolution has proved to be a wonderfully stable drillship. Predictions based on stability calculations and computer modeling indicate that the vessel will be affected little by wind and swell. The maximum roll-and-pitch limits for drilling are essentially the same for Glomar Challenger and JOIDES Resolution, although somewhat more severe conditions are required to reach those limits on JOIDES Resolution. The limits are dictated primarily by the necessity to restrict the bending moment of the drill pipe beneath the keel.

Drill Pipe Storage and Handling

Drill pipe is stored on the Western Gear Automatic piperacker, which has an extended capacity module to handle a total of 30,000 ft (9150 m) of pipe. Pipe is transported to the drill floor from three storage bays by the Automated Handling System using a dual elevator system to prevent mechanical damage to the special high-strength pipe.

Casing Storage

The number of linear feet of casing that can be stored on JOIDES Resolution depends upon the diameter of the casing, other equipment to be stored, and whether outside storage is used. There is, however, sufficient below-deck storage in the riser hold to ensure that operational capabilities will not be limited by inadequate casing storage.

Auxiliary Transportation

A 70 ft x 70 ft helipad is located on JOIDES Resolution's fantail, complete with a helicopter refueling station. The refueling capability allows a one-way helicopter range in excess of 500 nautical miles, a critical factor in transferring equipment and personnel and for emergency medical evacuations.

The vessel also has an inflatable Zodiac launch with an outboard motor. This kind of boat has been found to be the safest means of transferring personnel between vessels of disparate size. It can also be used for deploying and recovering various instruments.

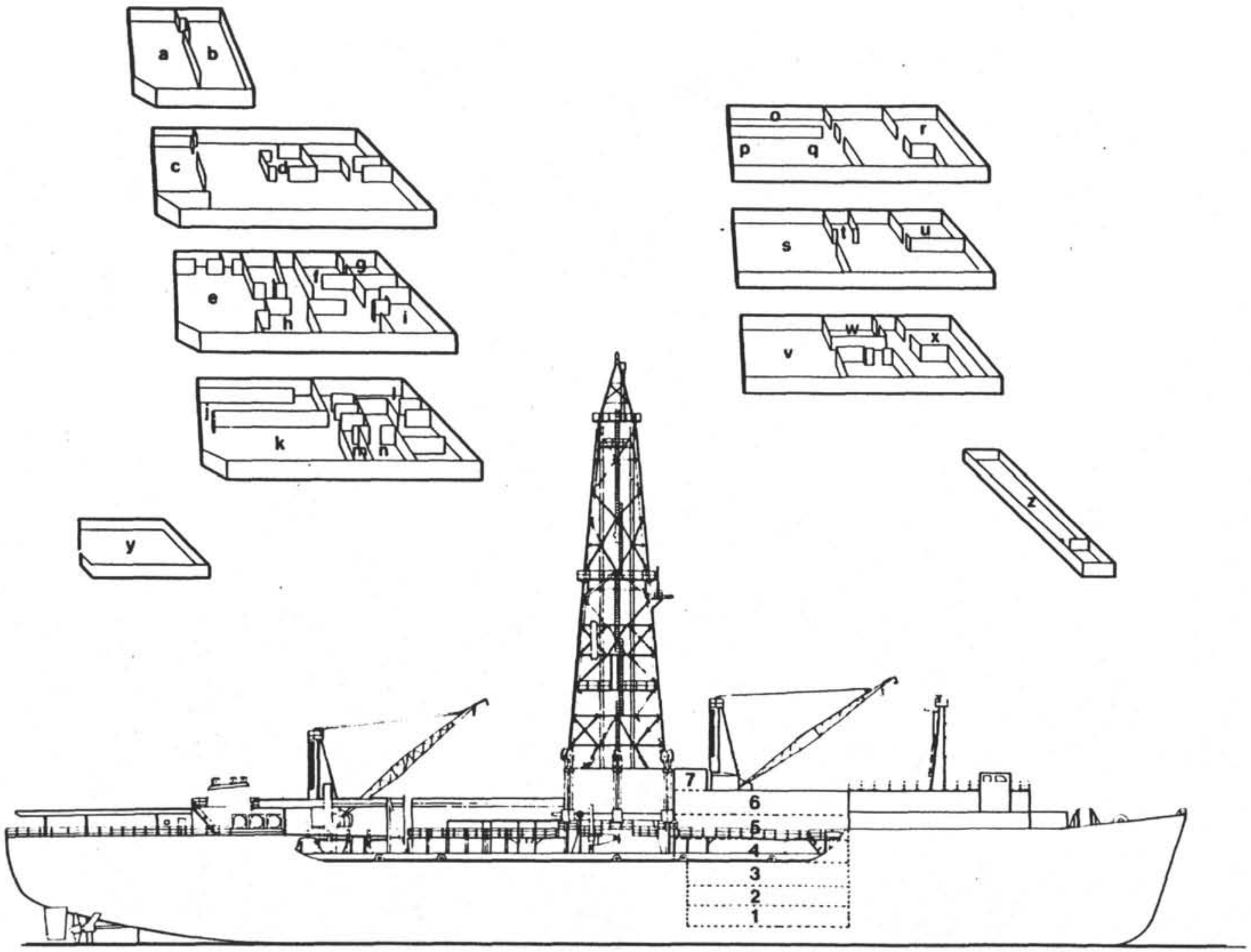
Living Quarters

Living quarters on JOIDES Resolution include one-person, two-person, and four-person rooms designed to accommodate a maximum scientific and technical crew of 50 people. Living quarters are located forward of the laboratory spaces with connecting passageways to the laboratories on two levels.

III. SCIENTIFIC LABORATORIES AND EQUIPMENT

The laboratories on JOIDES Resolution contain the largest and most varied array of seagoing scientific research equipment in the world (Figure 2). This modern drillship has more than 12,000 square feet of laboratory

ODP DRILLING VESSEL



a. Downhole Instruments, Logging
b. Downhole Instruments, Logging
c. Magnetics Lab
d. Core Splitting Lab
e. Chemistry Lab
f. Petrology Stations
g. Thin Section
h. Paleo Stations
i. Paleo Prep Lab
j. Computer
k. Science Lounge
l. Computer User
m. Yeoperson's Office
n. Co-Chief's Office
o. Electronic Shop
p. Photo Darkroom
q. Photo Finish Room
r. Fan Room
s. Core Storage Reefer
t. Cold Storage
u. 2nd Look Lab
v. Core Storage Reefer
w. Freezer
x. Storage
y. U/W Geophysics
z. Library

Figure 2.

space, divided into twelve major analytical areas. Each lab on JOIDES Resolution is designed to include state-of-the-art instrumentation. The selection of the lab equipment was based on advice from the JOIDES Advisory Group on Equipment and Laboratories (JAGEL) Committee.

The ODP scientific and technical staff at Texas A & M University hails from major oceanographic institutions all over the world, with many of the key personnel coming from the Deep Sea Drilling Project of Scripps Institution of Oceanography, the program's predecessor. This assures both fresh approaches to the problems encountered in deep-ocean drilling and a continuity of perspective toward gathering and disseminating scientific information. Each laboratory on JOIDES Resolution is staffed by specialists who have assisted in choosing the equipment systems and in preparing them for shipboard use. The Laboratory Officers who direct technical operations at sea have more than 40 combined years of experience on deep-ocean drilling vessels engaged in oceanographic research.

Underway Geophysics Laboratory

The following tasks are performed in the underway geophysics laboratory situated on the fantail under the helipad (Figure 3):

(1) collection, processing, and display of single-channel analog seismic data in real time,
(2) production of standard (SEG Y) format data tapes of all underway geophysical data for further processing and post-cruise archiving,
(3) collection and display of bathymetric (echo sounder) data,
(4) collection and display of magnetic data, and
(5) collection and display of certain navigational data.

Single-Channel Seismic System

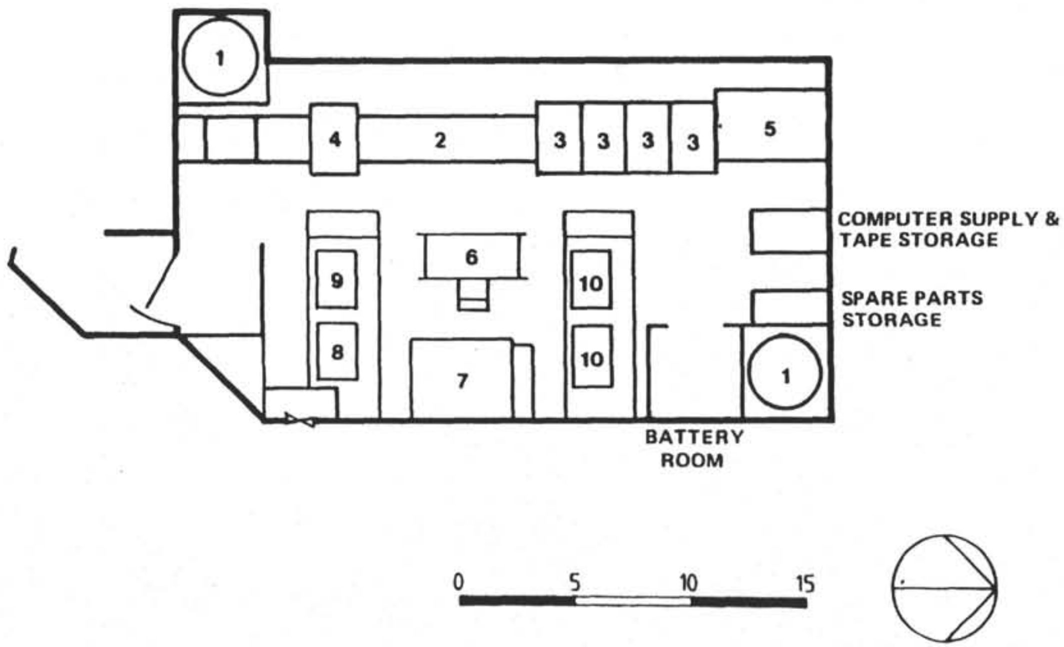
The single-channel seismic system records analog data, processes and displays it in real time, and generates raw data tapes. These seismic data are used to locate the optimum site to be drilled (where the beacon is dropped) and to correlate the drilled section with regional geology by relating cored material to regional seismic lines. Such correlations are aided by well-logging and physical properties results (see below).

The JOIDES Resolution seismic system has a super-micro 561 Masscomp computer as the central data recording and processing unit. The Masscomp is a 32-bit computer that allows data to be processed and displayed in real time on a 15-inch wide Printronix high resolution graphic printer (160 dots per inch). The raw data are recorded on standard SEG Y format data tapes for on-site (and post-cruise) processing; the final data are displayed on a 22-inch-wide Versatec plotter with a higher resolution display (200 dots per inch). Raw seismic data can also be displayed in real time on EDO 550 analog recorders, using only a streamer, amplifier, and filter. This analog mode also functions as backup in the event of irreparable equipment failure.

The software for the ODP shipboard seismic system was developed at the University of Texas at Austin in close cooperation with the scientific and

UNDERWAY GEOPHYSICS LAB

1. SUPPLY FAN
2. PRO-350 & MASSCOMP COMPUTERS
3. SEISMIC EQUIPMENT RACKS
4. SONOBUOY & MAGNETOMETER EQUIPMENT RACKS
5. VERSATEC PLOTTER
6. SCIENTIST'S WORK TABLE
7. WORK BENCH
8. 3.5 KHZ P.D.R.
9. 12.0 KHZ P.D.R.
10. FLATBED RECORDER



POOP DECK SECTION E

Figure 3.

technical staff at ODP. The package includes several types of data displays (scales and shapes), filtering and gain-control options, and more elaborate processing such as trace mixing, deconvolution, and migration. Processing and display are done as the data are collected. The seismic system was designed to allow for expansion as new scientific experiments are added (e.g., vertical seismic profiling).

The standard seismic sources available for use aboard JOIDES Resolution include two 80-cubic-inch and one 400-cubic-inch waterguns from Seismic Systems. The high resolution provided by these waterguns is necessary for accurate correlation between the drilled section and the regional stratigraphy. The following airguns also are on board and available for use: one Bolt 1500C with chambers of 120 or 300 cubic inches and three Bolt 600A with chambers that can vary from 5 to 80 cubic inches. The smaller waterguns or the airguns can be used while a ship is en route at high speed (12-13 knots); the larger gun can be towed while approaching a drill site or when the ship is traveling at slower speeds because of a specific scientific need.

Bathymetric data

For displaying bathymetric data, there are 3.5-kHz and 12-kHz Precision Depth Recorder systems which consist of sound transceiver, transducer, and recorder. Either system can be operated with a Raytheon CESP-III Correlator that gives an approximately 20db signal-to-noise improvement over a standard system. The correlator is normally used with the 3.5 kHz system; changing the correlator over to the 12 kHz recorder requires about half an hour of card and connector changes.

Magnetic data

Magnetic data from a Geometrics 801 proton precession magnetometer are recorded on the header of the seismic tapes at one reading per seismic shot. These data are also displayed on a strip-chart recorder.

Navigational Data

The following data are displayed and collected in the lab: time, ship's speed, ship's heading, distance traveled, relative wind speed, relative wind direction, gun and field timebreak times, field timebreak delay, shot count, streamer depth, gun depths, and, in the future, satellite navigation fixes. Satellite navigation and Loran C units are located on the ship's bridge.

Sedimentology Laboratory

The core lab, located on the bridge deck, is divided into the core entry lab, core splitting room, sampling area, and sedimentology lab (Figure 4). The core splitting room is isolated from the rest of the core laboratory. Full-length (about 9.5-m) cores in plastic liners are retrieved from the drill hole and cut into 1.5-m sections on the catwalk outside the core entry lab. The sections are brought in to be labeled and entered into the central computer data base. After physical properties (GRAPE) and paleomagnetics whole-round core measurements are made, the

1. SAFETY SHOWER & EYE BATH
2. ELECTRONICS RACK
3. FAXITRON (X-RAY)
4. COMPUTER TERMINAL
5. THERMAL CONDUCTIVITY
6. G.R.A.P.E.
7. CONSOL/TRIAX
8. MINI-SPIN MAGNETOMETER
9. A/C DEMAGNETIZER
10. PENTA-PYCNOMETER
11. THERMAL DEMAGNETIZER
12. BALANCE ON GIMBALED TOP
13. CRYOGENIC MAGNETOMETER
14. TRIM SAW
15. VANE SHEAR
16. VELOCIMETERS
17. OVEN OVER HOOD
18. HEAT SEALER
19. CAPSTAN MOTOR & CORE SPLITTER
20. TERMINAL
21. MINI-CORERS
22. FELKER SAW
23. MICROSCOPE STATION
24. CLOSE-UP PHOTO TABLE
25. DATA BOARD
26. RIG FLOOR MONITORS

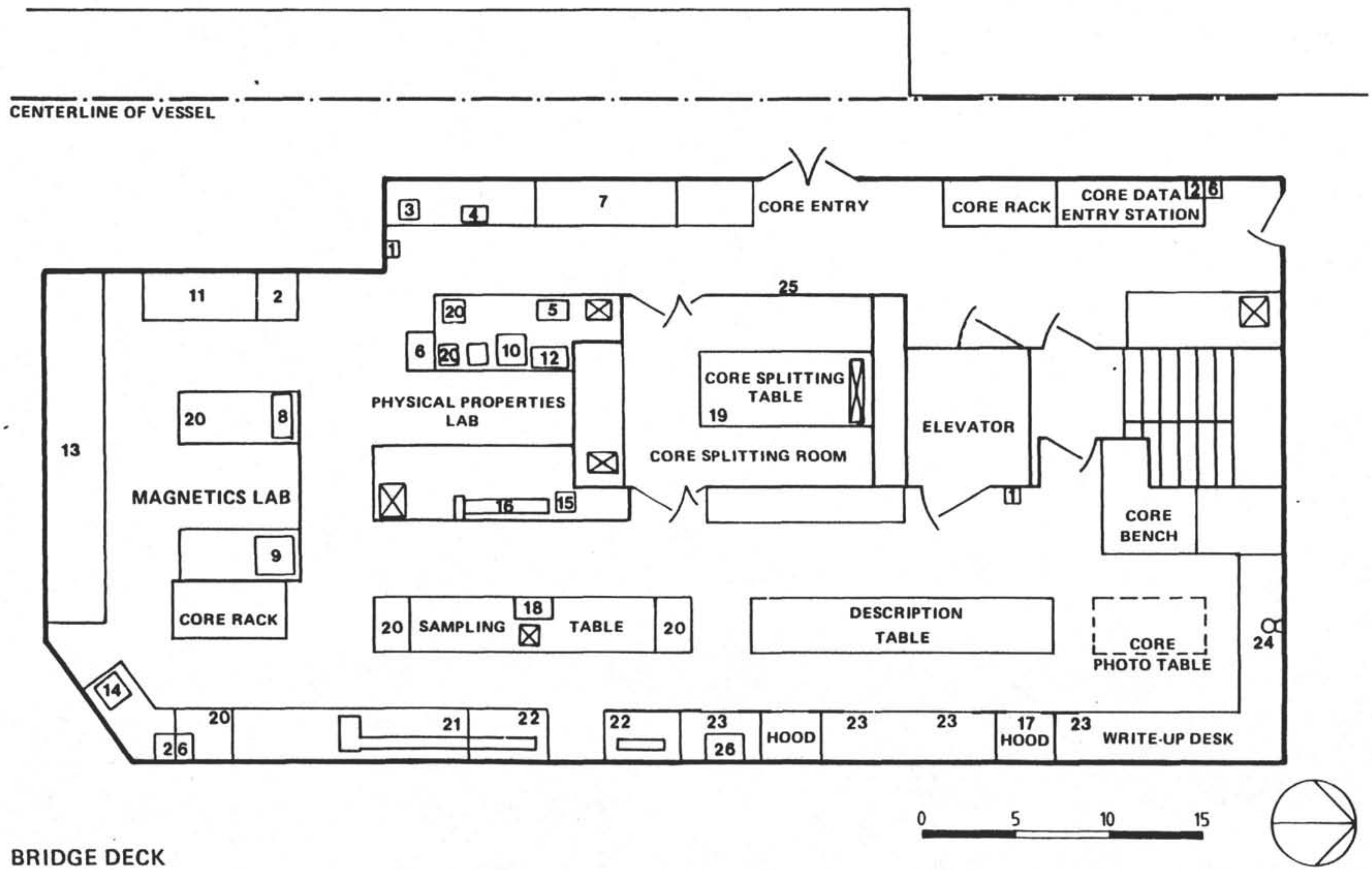


Figure 4.

sections are cut longitudinally into work and archive halves in the core splitting room and carried into the sampling and sedimentology labs for core description and sampling.

The sedimentology lab contains separate description, sampling, and photography tables, as well as bench space and microscope stations. Smear slides are prepared using hot plates and Isotemp ovens under a benchtop fume adsorber. Available mounting media include: Canada Balsam, Hyrax, Piccolite, Permount, Gum tragacanth, clove oil, and a German synthetic Canada Balsam (Eukitt). The following stains and dyes are also available: Methylene blue, Malachite green, Alizarin red S, Sanfranin O, and Rose bengal.

The optical equipment located in the sedimentology lab is similar to that which is available in the paleontology and petrography labs (see below). Equipment includes two Zeiss standard WL microscopes and two Zeiss SR stereomicroscopes. Oculars, objectives, micrometers, and filters are interchangeable among all the Zeiss microscopes on board. The microscopes are all supported by vibration isolation systems.

Core sampling equipment available in the sampling lab includes Felker radial arm saws, a drill press with diamond coring bits and minicorer, heat guns, and heat sealers. Computer terminals are conveniently located for direct input of sampling data and to print sample labels.

Physical Properties Laboratory

JOIDES Resolution's physical properties laboratory (Figure 4) contains equipment for analysis of the physical, thermal, mechanical, and acoustical properties of sediments and rock.

The GRAPE (Gamma Ray Attenuation Porosity Evaluator), originally used on *Glomar Challenger*, has been extensively reconfigured to scan cores vertically. A mechanical stage transports the shielded, 10 millicurie ^{137}Ce source and its detector past vertical core sections at rates up to 30-50 cm/min. A second range of slower speeds (5-30 cm/min) is available for greater resolution. A Digital Equipment Corporation PRO 350 computer monitors the density and automatically senses anomalous areas that warrant a second slower scan; alternatively, scan speed can be under manual control. Data are displayed and logged at the dedicated terminal. The GRAPE device can also be used for two-minute counts on discrete samples.

Bulk and dry density, porosity, and water content analyses are easily completed via a computerized balance system and a Quantachrome automated pycnometer. The pycnometer provides accurate volumetric measures on up to five samples at a time. Standard submerged weighing capabilities are also provided.

Two transducer configurations are available for shear and compressional wave velocity analyses. A blade-type transducer mount for use in soft sediments contains both a bender element for shear wave generation and a compressional element. Rocks and more lithified sediments are tested using a frame-type transducer mount. Pzt-5a crystals with operating frequencies of 500 kHz and 1 MHz are mounted on pneumatically controlled rams in the frame. Linear potentiometers and electronic calipers provide measures of distance between transducers. A Tektronics package consisting of oscilloscope, programmable universal timer/counter, and digital multimeter permit easy setting of trigger levels and display microsecond delay time and length of travel path.

Shear strength measurements of sediments are easily obtained with a motorized vane equipped with torque transducer and rotational outputs. The output data are recorded on a Hewlett Packard XY flatbed recorder.

A GDS consolidation/triaxial testing system provides analyses of sediment stress history, strength, mechanical properties, and permeability. Data collection and reduction for this system are computerized through an HP-85B link to three digital pressure controllers. Permeabilities are obtained through indirect computation of consolidation results or directly from a low hydraulic gradient test using a syringe flow-pump system.

Thermal conductivity equipment, designed at Woods Hole Oceanographic Institution, has five needle probes for simultaneous measurements. Data are collected, reduced, and displayed by a dedicated PRO 350 computer. Thermal conductivity data used in conjunction with data from the temperature measurement tool (see Downhole Tools section of this paper) provide estimates of heat flow.

A Hewlett Packard Faxitron allows slab sample radiographs to be made on board ship. An autoexposure unit, extension collar, and plexiglass sample trays facilitate use of this equipment.

Other physical properties laboratory equipment includes hand-held Torvanes, soil test penetrometers, Atterberg limit devices, an Isotemp forced convection oven, and a dual-bladed trim saw.

Paleomagnetics Laboratory

The paleomagnetics laboratory (Figure 4) features two magnetometers: a three axis, pass-through 2G cryogenic (superconducting) magnetometer and a fluxgate spinner magnetometer. The cryogenic magnetometer, operating in either whole core scan or discrete sample mode, is linked to a PRO 350 microcomputer that controls pass-through movement and acquires magnetization intensity values from each of the three axes. A Bartington susceptibility meter equipped with whole-core scanning loop sensor operates in-line with the cryogenic magnetometer's pass-through system to give a continuous record of downcore susceptibility. A separate single-sample sensor is used to measure discrete sample susceptibilities. A low-field, three axis, alternating field demagnetizer (up to 10 mT), operates in line with the cryogenic magnetometer and is also linked to the PRO 350. The magnetization remaining after alternating field treatment is measured by the cryogenic magnetometer on a second pass-through.

A Molspin spinner magnetometer, interfaced to an Epson HX-20 microcomputer, measures very strongly magnetized samples and serves as a backup to the cryogenic magnetometer. General paleomagnetic lab support equipment includes a Schonstedt fluxgate probe magnetometer for monitoring ambient magnetic fields within the magnetic shields and around the lab area and a Schonstedt single-axis demagnetizer capable of demagnetizing discrete samples up to 1000 Oe.

Chemistry Laboratory

The shipboard chemistry lab is located on the foc'sle deck (Figure 5). Most ODP cruises include two chemists on the technical staff who provide full-time coverage in the chemistry lab and assist shipboard organic and inorganic geochemists. The chemists standardize, run, and maintain the analytical apparatus, prepare and log samples, and finalize data.

Gas Monitoring Equipment

Gas monitoring equipment in the chemistry lab includes two Hewlett Packard 5890 Gas Chromatographs, one dedicated to hydrocarbon monitoring for natural gas analysis and the other with a capillary column.

The gas chromatograph configured for natural gas analysis has one 10- and two 6-port switching valves. The three columns in this GC are a DC200 that separates propane through hexane, a Poropak for separating methane, ethane, and carbon dioxide, and a Molecular Sieve for methane, oxygen, and nitrogen. This arrangement allows for very precise separation of hydrocarbons, with a run-time of about 20 minutes. A thermal conductivity detector (TCD) and flame ionization detector (FID) are hooked up in series to this unit. The GC is connected via an HP-1B loop with A/D converters to the Lab Automation System (LAS), which converts and integrates data output, generating a customized report for each run. Two 3392 Integrators are backups to this computer system. The LAS consists of a 600+ CPU and a 28-megabyte Winchester disk.

The LAS also runs the capillary column gas chromatograph, which is plumbed with a split/splitless 50m fused quartz small-bore capillary column also attached to the TCD/FID series. Because the column is quartz, there is better separation between similar compounds' peaks. Alternatively, this GC can be run with a single Poropak column for separation of light hydrocarbons. This option allows very quick analysis of hydrocarbon shows that may directly affect drilling operations.

The capillary column gas chromatograph is available for the special research projects of shipboard geochemists. In order to determine absolute concentrations of hydrocarbons in sediment pore water and to relate these to organic carbon contents, a device can be attached to the GC system which allows carrier gas stripping of hydrocarbons from sediment samples.

Organic Carbon

The Delsi Nermag Rock-Eval II Plus TOC is a microprocessor-based instrument for whole-rock pyrolysis, used to rapidly evaluate type and maturity of organic carbon, calculate petroleum potential, and detect oil shows. It has a printing recorder and an automatic sampler that holds 48 samples.

A Perkin-Elmer CHNS Elemental Analyzer is available for measuring amounts of organic carbon, hydrogen, nitrogen, and sulfur in sediment samples. The unit consists of a 240C Elemental Analyzer, 3600 Data Station, autosampler for 60 samples, and thermal printer. Analyses typically take 12 minutes per sample, with extensive sample preparation time.

CHEMISTRY LAB

1. BALANCE TABLE GIMBALED
2. AUTOMATED C-H-N-S ANALYSER
3. ROCK EVALUATION SYSTEM
4. CANOPY HOOD
5. FUME HOOD
6. PRESSES
7. ION CHROMATOGRAPH
8. AUTOMATIC TITRATION
9. FREEZE DRYER
10. FREEZER BELOW
11. WATER PURIFICATION SYSTEM
12. GRINDERS
13. CHEMICAL HOOD
14. HYDROFLUORIC ACID HOOD
15. GAS STORAGE & CENTRAL REGULATOR
16. SAFETY SHOWER & EYE BATH
17. HP 1000 COMPUTER FOR CHEMISTRY LAB
18. GAS CHROMATOGRAPH
19. CARBONATE ANALYZER

XRD/XRF

20. ELECTRONICS/COMPUTER CABINET
21. XRF MONITOR
22. PW/1730 X-RAY GENERATOR
23. GAS BOTTLE STORAGE
24. DEC. MINICOMPUTER AND XRD CONTROLLER
25. HEAT EXCHANGER
26. X-RAY SPECTROMETER
27. XRD PW 1720 GENERATOR
28. COLOR PLOTTER
29. COLOR TERMINAL

PETROLOGY STATIONS

30. MICROSCOPES
31. COMPUTER TERMINAL

THIN SECTION

32. SAW GS-10
33. PETRO-THIN GRINDER
34. LOGITECH LP - 30 GRINDER POLISHER
35. BUEHLER LAP WHEEL
36. W-20 VAC IMPREGNATOR
37. FINE POLISHER
38. SLIDE PREP
39. MICROSCOPE

PALEO PREP LAB

40. CHEMICAL HOOD
41. STEAM WASHER BELOW
42. CANOPY HOOD
43. PALEONTOLOGY REFERENCES

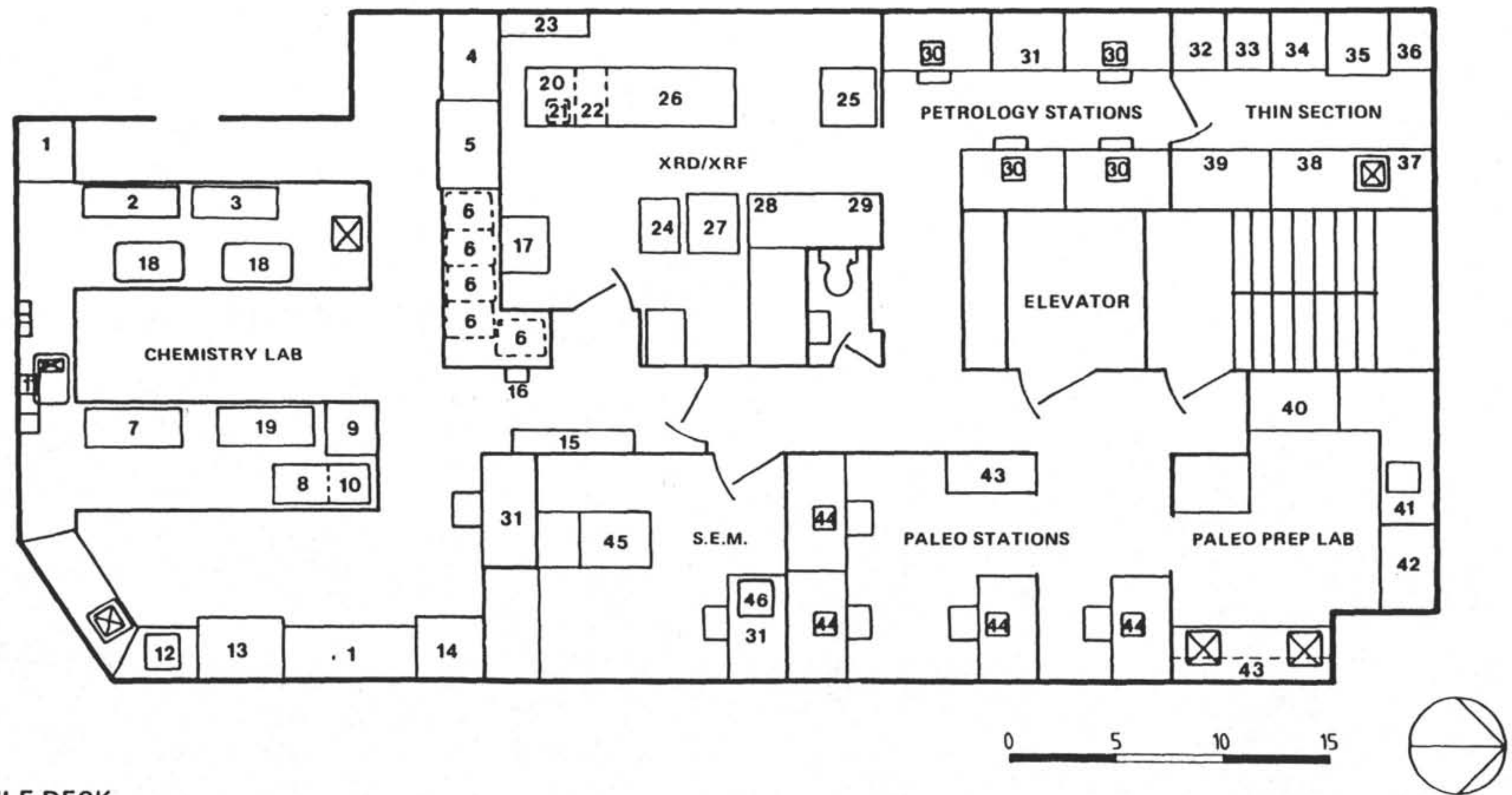
PALEO STATIONS

44. MICROSCOPE/TERMINAL

S.E.M.

45. SCANNING ELECTRON MICROSCOPE
46. MICRO FILM/MICROFICHE READER

CENTERLINE OF VESSEL



FOC'S'LE DECK

Figure 5.

A Turner Fluorometer in the chemistry lab and a Halliburton ultraviolet ray box in the core lab produce qualitative analyses of hydrocarbon shows.

Carbonate Analysis

A Coulometrics analyzer produces accurate photometric measurements of carbonate constituents in sediments with a precision of ±1% and run-time of 20 minutes. The carbonate bomb, with a precision of ±5% and a 5-minute run time, serves as a backup. The bomb is a simple hand-held unit with a pressure gauge on top, identical to those used previously on Glomar Challenger. Both devices use concentrated hydrochloric acid to dissolve all carbonate compounds in a small dried and ground sediment sample.

Interstitial Water Program

The shipboard Dionex Ion Chromatograph has three columns: one for anions, a second for monovalent cations, and a third for divalent cations. The chemists measure amounts of lithium, sulfate, calcium, magnesium, sodium, and potassium, with the potential for chlorinity, nitrate, and phosphate measurements, in interstitial water squeezed from whole round core samples. The IC is microprocessor-controlled, with data passed to the LAS, and includes an autosampler that can hold 56 samples.

The lab's automated Brinkman titration system consists of an HP86B microprocessor programmed to interface with a Metrohm 605 pH meter and a Metrohm 655 Dosimat. It measures the pH, alkalinity, and chlorinity of interstitial water and can also be used for calcium and magnesium measurements.

Measurements of salinity or total dissolved solids of interstitial water are made with a temperature-compensated refractometer. Several drops of pore water are used for the analysis, with a resultant precision of ±1%.

Colorimetric measurements of ionic concentrations in pore water samples are conducted on the Bausch & Lomb Model 1001 Spectrophotometer. With a wavelength range from 190 to 950 nm, ionic concentrations of nitrate, silica, ammonia, bromide, and other common pore-water constituents can be measured. The spectrophotometer accommodates a variety of cell types and sizes, facilitating the precise analysis of small (microliter) sample volumes.

Associated Lab Equipment and Chemicals

The chemistry lab contains a number of other lab instruments necessary for shipboard geochemical analyses. There are four Carver hydraulic presses, with one hydraulic pump for every two presses. Each press is capable of 25 tons constant pressure. Two gimballed tables hold balance systems: the first table has twin Cahn 29 balances for small samples (up to 1250 mg), and the second table has twin Scientech balances for larger samples (1 mg to 50 g). A Labconco 39-port freeze drier is available for removing water from sediment samples and can hold 39 individual samples of up to 15 cc each. The ship's potable water is run through a Barnstead water purifier to produce both lab and reagent (18 ohm) grade waters by osmotic pressure. There are hardened steel ball Spex mill grinders and electric agate mortar/grinders for homogenizing dried sediment samples, and a shatterbox for pulverizing basalt or hard-rock samples. One fume hood in the chemistry lab is for solvents, and two others are for chemical reactions. An ashing furnace is located in the adjacent X-ray lab (Figure 6).

There are two hydrogen generators in the chemistry lab. Bottled helium and oxygen are kept aboard the ship. The ship's pressurized air system is available throughout the lab structure and is appropriately filtered.

The chemistry lab contains a very complete set of standard lab chemicals: acids, bases, solvents, etc. There is an ample supply of laboratory glassware and support equipment aboard ship for use during the cruise.

Petrography, Thin Section, and S.E.M. Laboratories

The petrography and thin-section laboratories (Figure 5) have been outfitted to make thin sections by traditional methods as well as to provide large quantity output. When only one or two thin sections are required, they are made "by hand" using a Buehler Petro-Thin thin-sectioning system and thin-section grinder. When large batches of thin sections are requested, the Logitech LP-30 lapping machine can produce approximately 200 high-quality thin sections in a 40-hour week. The sections are polished on a Logitech WG-2 polishing system. Special support equipment in the thin-section lab includes a Logitech CS-10 thin section cut-off saw and IU-20 vacuum impregnation unit used to impregnate porous or friable specimens with synthetic resins. Delicate or critical samples are cut on a Leco VC-50 Vari-speed diamond saw. Eight microscopes are available for thin-section and rock-sample study: four Zeiss standard WL polarizing petrographic microscopes with reflected light, photographic, and video capabilities; two Zeiss photomicroscopes (type III POL), which can accept both 35mm and Polaroid camera attachments; and two standard Zeiss SR stereoscopes. All microscopes have interchangeable accessories. Petrographic descriptions of thin sections are recorded in the ODP database through use of computer terminals located adjacent to microscope stations.

The shipboard International Scientific Instruments SX-25 Scanning Electron Microscope is located next to the petrography lab. It has a continuous magnification range from 15x to 100,000x and working distances from 8 mm to 38 mm, allowing both high resolution and large depth of field. The S.E.M. operates with an accelerating voltage of 25 kV and uses Polaroid Type 52 (positive) and Type 55 (positive and negative) films. It is capable of backscatter electron imaging as well as secondary electron imaging.

XRF/XRD Laboratory

JOIDES Resolution's XRF/XRD lab (Figure 5) is the most advanced of its kind on any ocean research vessel. An Applied Research Laboratory 8400 Hybrid Spectrometer is used for X-ray fluorescence analysis. This instrument is fully microprocessor-controlled with automatic sample loading. It has an end-window Rhodium X-ray tube, 60 kV generator, and two independent goniometers with scintillation, flow proportional (P-10), and sealed Kr detectors. The following analytical crystals are available:

LiF 200, LiF 220, LiF 420, PET, TLAP, GE, and ADP. The system can be upgraded in the future with either a third goniometer, several single-channel monochromators, or a SiLi detector for energy dispersive analysis. Supporting the 8400 is a DEC Micro-11 computer with a 28-megabyte Winchester disk drive. Software support includes quantitative, qualitative, statistical analysis, and fundamental parameters (XRF-11) programs.

A Philips ADP 3520 is used for X-ray diffraction analyses. The ADP 3520 is fully microprocessor-controlled with automatic sample loading and is configured with a Cu X-ray tube and monochromator. A second DEC Micro-11 computer with a 28-mb Winchester disk drive supports this system. Software support includes quantitative, search-and-match of the JCPDS and user data bases, line profile analysis, and statistical analysis programs.

Equipment available for sample preparation includes a tungsten-carbide shatter box, agate auto-mortar and pestle, steel mixer mill, Claisse fluxer-bis (Au-Pt crucibles), programmable ashing furnace, and various types of fluxes: (1) 47% lithium tetraborate, 37% lithium carbonate, 16% lanthanum oxide, (2) 90% lithium tetraborate, 10% lithium carbonate, (3) boric acid (powder), (4) $NaNO_3$ (powder), and (5) NaI.

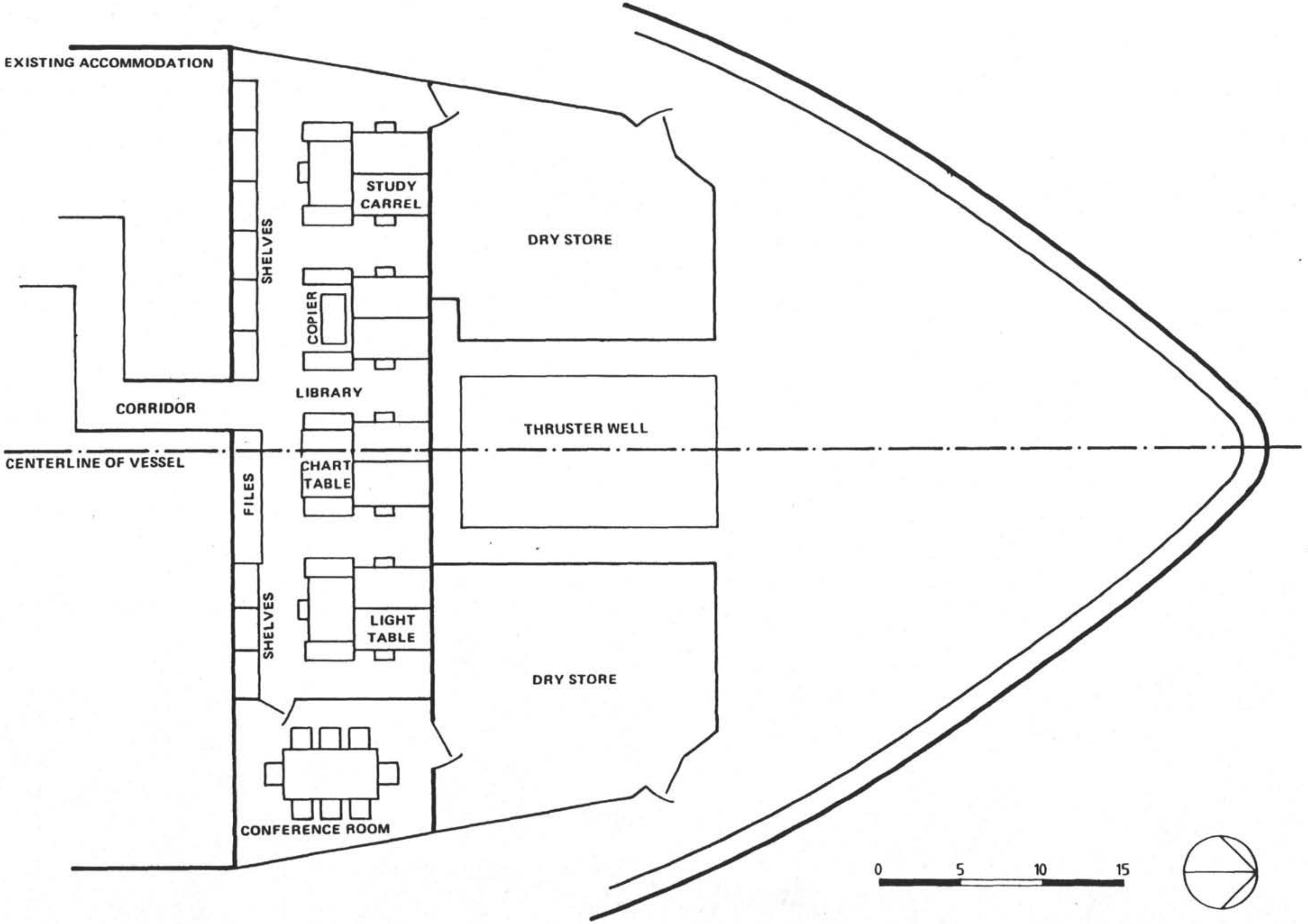
Paleontology Laboratory

The paleontology laboratory aboard JOIDES Resolution is divided into adjoining preparation and microscope study labs (Figure 5). The paleo-prep lab is set up for processing micropaleontological samples and making slides. It contains standard equipment such as sieves, hot plates, infra-red lamps, ovens and chemicals, as well as a Labconco steam laboratory glassware washer and benchtop slide warmers with fume adsorbers. Optical equipment and a library of reference materials required for micropaleontological research are located in the microscope study lab. The optical equipment includes two Zeiss WL microscopes with a full range of objectives, including those for Nomarski and phase contrast microscopy, and four Zeiss SR stereomicroscopes with magnification changers and built-in illuminators. A Zeiss photomicroscope (type III POL) is located in the petrography lab for use by paleontologists. Polaroid and 35mm camera backs and a Sony TV video system are available for adaptation to any microscope. Other optical equipment includes drawing tubes to aid in making sketches of microscopic images and stage and eyepiece micrometers.

A paleontological reference library is also housed in the microscope study room. This collection of texts, journals, and reprints is catalogued in a separate paleontology library catalog and cross-indexed in the main shipboard science library catalog.

Science Library

JOIDES Resolution's shipboard science library (Figure 6) contains more than five hundred publications for reference and assistance in the shipboard analyses of drilling results. There are basic reference works, a complete set of DSDP Initial Reports, maps, reprints, and key monographs representing various fields of geology and oceanography. The holdings are catalogued under the Library of Congress system. A separate paleontology



MAIN DECK SECTION C

Figure 6.

library housed in the paleontology laboratory is cross-indexed in the main shipboard science library card catalog.

Other library facilities include a conference room, ten study carrels, map/chart table, computer terminal, and photocopy machine. A paperback collection for popular reading is kept here and in the science lounge.

Science Lounge and Office Space

The science lounge, located on the main deck of the laboratory facility (Figure 7), is a comfortable recreational area featuring a stereo cassette tape system, public address system, large screen television, radio, video recorders, and video games facilities. Slide, overhead, and 16mm movie projectors are available for scientific or recreational use. A selection of paperbacks and magazines is provided for leisure reading.

The Co-Chief Scientists' and Yeoperson's offices are also on the new main deck. Prime data files are kept in these offices. Offices for the Laboratory Officers and Operations Superintendent are on the ship's bridge deck.

Shipboard Computer Facilities

JOIDES Resolution is equipped with a research-oriented computer system (Figure 7) designed to perform routine clerical and arithmetical tasks in order to free scientists and technicians for more creative research activities.

The central computer system assists in performing such diverse functions as core-log entry, core sampling, data analysis, drill string engineering, presentation graphics, microscopy, chemistry, inventory control, office automation, and manuscript preparation. This is accomplished through conveniently located microcomputer workstations arranged in a distributed processing architecture. A central theme in the design of the shipboard system is the offloading of common tasks onto the workstations for more efficient use of the central system.

The shipboard system is based on the VAX 11/750 super-mini computer using PRO 350 microcomputers as intelligent workstations. The central system and its associated components are housed in the computer complex on the main deck of the laboratory structure. This facility is climate-controlled and provides an office for the shipboard System Manager and a user room with several workstations and system peripherals.

The central VAX system is equipped with four million bytes of random access memory (RAM) and provides high speed computational power for arithmetic processing. The system also provides archival storage of shipboard data on one gigabyte (about 1.6 million typed pages) of high speed mass storage and two magnetic tape drives that function at 1600 bpi. Other system peripherals include a laser printer, two high speed printer/plotters, a 36" drum plotter, a bar code terminal, and two daisy-wheel letter quality printers. Each major system component has a redundant twin providing a backup in the event of irreparable component failure.

Figure 7.

COMPUTER

1. POWER CONDITIONER
2. VIDEO SYSTEMS CONTROL
3. TAPE STORAGE
4. DISC DRIVES
5. STORAGE CABINET
6. VAX-CPU

COMPUTER OFFICE

7. VAX SYSTEM CONSOL
8. TAPES & STORAGE

COMPUTER USER

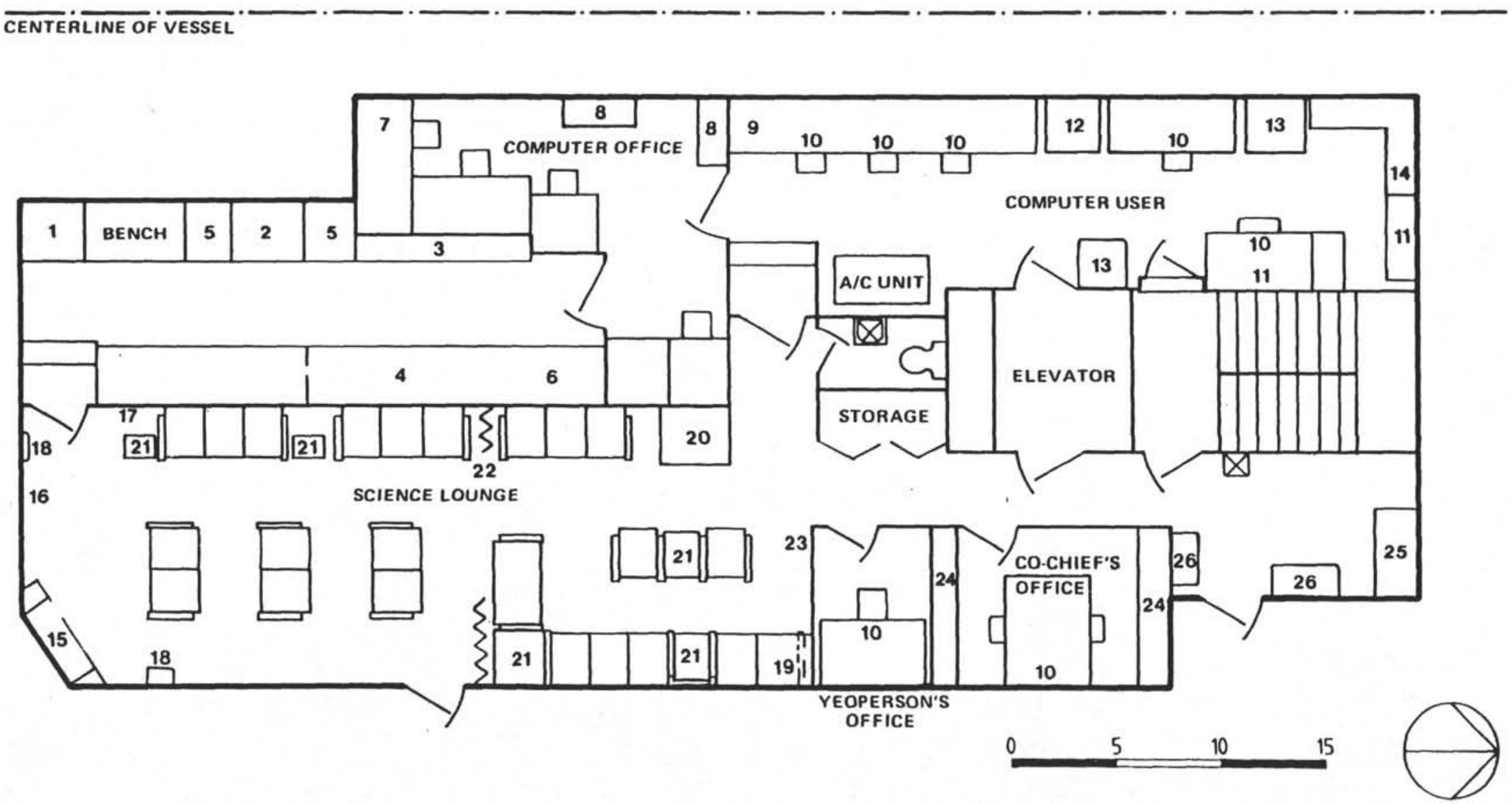
9. DAISY PRINTER
10. TERMINALS
11. PLOTTER
12. LASER PRINTER
13. LINE PRINTER
14. TAPE STORAGE RACKS

SCIENCE LOUNGE

15. VIDEO RECEIVER/AMP STEREO, SONY U-MATIC, VCR-STEREOS, BETA/ VHS, LASER DISC PLAYER, TAPE & VIDEO DISC LIBRARY, STEREO SPEAKERS
16. LARGE SCREEN COLOR T.V.
17. WALL OF REMOVABLE ACCESS PANELS
18. SMALL WALL-MOUNT SPEAKERS
19. RIG VIDEO MONITOR, CEILING MOUNTED
20. STEREO CASSETTE PLAYER, MOVIE PROJECTOR, SLIDE PROJECTOR, OVERHEAD PROJECTOR, GAMES & PUZZLES, HEADPHONES, MAGAZINES, VIDEO GAMES
21. COFFEE TABLE
22. FOLDING CURTAIN
23. SCREEN & DEMO BOARD

CO-CHIEF'S OFFICE

24. SHELVES
25. COPY MACHINE
26. FILE CABINET



NEW MAIN DECK

The development of a networked satellite communications capability will allow the shipboard host computer system to access a similar VAX system at ODP headquarters in College Station, Texas. This communications link will operate at 2400 bits per second through the Marisat satellite communications system. Eventual capabilities of the system include access to scientific data from past cruises, shipboard inventory control, and electronic mail.

A complete list of software available on the system is provided in the accompanying Shipboard System Description with the following groups represented: word processing, databases, presentation graphics, spreadsheets, computer language compilers, and specialized application programs. Computer-based instruction courses are available on several topics and a complete set of user documentation is available.

Most of the daily work load will be accomplished directly on the PRO 350 workstations. These PDP-11 based microcomputers each contain 512 bytes of RAM memory and a five megabyte or larger hard disk. The units also contain two 5.25" floppy disk drives. Each of the workstations is configured for a specific set of tasks. Word processing stations, for example, are connected to a local dot matrix printer and have word processing software installed on the system's hard disk. Other specialized workstation component lists are included in the Shipboard System Description.

The PRO 350 P/OS operating system is exceptionally easy for a first-time user to learn and provides an integrated software environment from which to run various speciality software. Tutorials and classroom instruction are provided by the Shipboard System Manager and Yeoperson during each cruise.

Each workstation communicates with the central VAX via a hardwired asynchronous line. These lines normally operate at 1200 bits per second but are capable of operating at speeds up to 9600 bits per second. Generally, data and text are entered and revised on the PRO 350 without assistance from the VAX. The final product is then downloaded to the VAX for archival storage.

Computer subsystems in the underway geophysics, chemistry, X-ray, and magnetics laboratories provide dedicated processing power for specialized tasks. For these areas it was determined that commercially available computer systems could accomplish the task in a more powerful and cost-effective manner than custom software developed for the central VAX system. These subsystems are described in the appropriate laboratory section above.

Shipboard System Description

1. Host system:

   - VAX 11/750 CPU with 4-meg RAM memory
   - One gigabyte mass storage (about 1.6 million typed pages)
   - Two magnetic tape drives
   - 48 port asynchronous communications capability
   - 2400 baud synchronous satellite communications link
   - Redundancy in all major system components

2. Workstations:

- Wordprocessing stations (12)
    - PRO 350 microcomputer
    - Dot matrix printer
- Microscopy stations (10)
    - PRO 350 microcomputer
    - Dot matrix printer
    - Microscope stage interface
- Core sampling stations (3)
    - PRO 350 microcomputer (hard disk)
    - Dot matrix printer
    - Sample bag printer
    - Sampling station interface
- Data acquisition station (3)
    - PRO 350 microcomputer (hard disk)
    - Real time interface
- Art station (2)
    - PRO 350 microcomputer (hard disk)
    - Digitizer
    - CADD software
    - Plotter
- Graphics CRT (10)
- High resolution graphics terminal (4)

3. System peripherals:
    - Laser printer (1)
    - High speed printer/plotter (2)
    - 36" drum plotter
    - Bar code terminal
    - Letter quality printer (2)

4. Software:

    - VAX VMS operating system
    - P/OS OPERATING SYSTEM (PRO 350)
    - BASIC
    - COBOL
    - FORTRAN
    - PASCAL
    - DATATRIEVE
    - System 1032 (Relational database)
    - CT*OS (Wordprocessing)
    - RS/1 (Data Analysis & graphics)
    - DEC CALC (Spreadsheet)
    - Corelog
    - Core Sampling
    - Core Description

- Core Testing
- Inventory Control
- Data Acquisition (GRAPE, etc.)

5. Computer subsystems:

   - Underway Seismic
     - Masscomp UNIX system
     - Underway interface

   - Gas Chromatography and Chemical Laboratory
     - HP Lab Automation System
     - A/D interfaces
     - Automatic titrator (HP 86B)
     - Carbonate analyses

   - X-ray Laboratory
     - XRF Micro-11 system
     - XRD Micro-11 system

   - Magnetics
     - Epson HX-20

6. Functions to be assisted or performed:

   - Corelog
   - Coresampling
   - Underway geophysics
   - Geochemistry
   - Drill string engineering
   - Microscopy
   - Presentation graphics
   - Inventory control
   - Data analysis
     - Office automation
     - Manuscript preparation and tracking

Photography Laboratory

The shipboard photography laboratory, located on the upper 'tween deck, has two sections: a wet/darkroom and a dry/copy mounting area (Figure 8). The lab's capabilities include facilities for black-and-white film processing, both manual and with a Kreonite print processing machine, and color film processing using a Wing-Lynch Model 4. The Wing-Lynch Processor allows the shipboard photographer to develop Ektachrome transparencies in 35mm, 2 1/4", and 4" x 5" formats using Kodak E-6 chemistry. These facilities assure that a photographic core record can be completed aboard ship and allow immediate reshooting, if necessary, of the important color transparencies of fresh archive core halves. The Kreonite print processor, a 16" floor-mounted model, is used to process the 8" x 10" black-and-white core photos (used on board and for publication), along with public relations photos, core close-ups, photomicrographs, and X-ray photographs. Both the film and print processors are modified for shipboard use. A Beseler enlarger is used to make black-and-white prints.

PHOTO DARKROOM

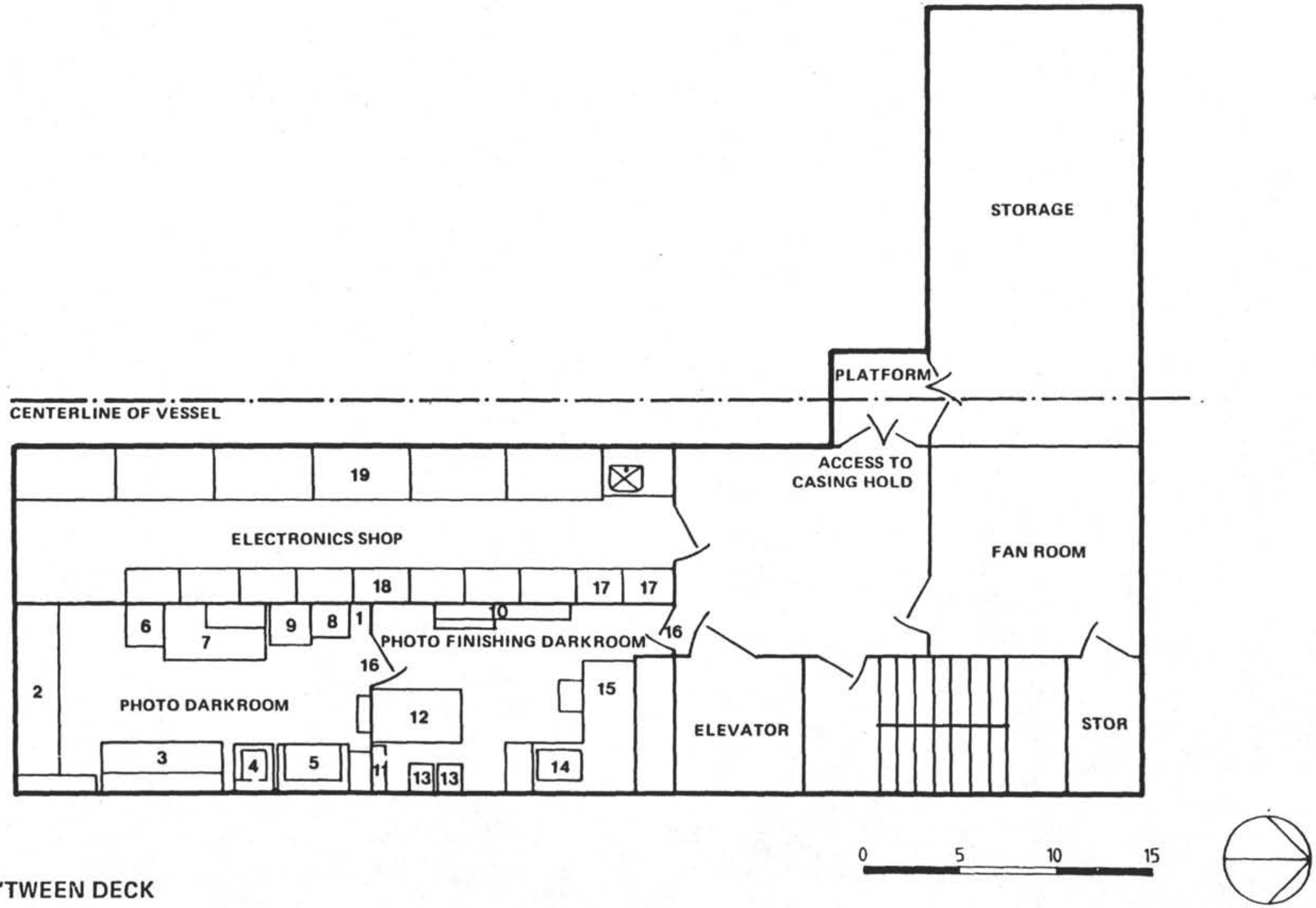
1. NITROGEN BOTTLES & REGULATORS
2. FINISHING AREA
3. TRAY PROCESSING SINK
4. LIGHT TIGHT DRAWERS & VIEW LIGHT
5. ENLARGING STATION
6. FILM PROCESSOR
7. AIR TEMPERED FILM PROCESSOR
8. FILM DRYING CABINET
9. FILM REFRIGERATOR

PHOTO FINISHING DARKROOM

10. WASH UP SINK
11. THERMOSTATIC WATER MIXING
12. AUTOMATIC PRINT PROCESSOR
13. PORTABLE CHEMICAL MIXERS
14. COPY STUDIO
15. FINISHING DESK
16. LIGHT TIGHT DOORS

ELECTRONICS SHOP

17. FILE CABINETS
18. STORAGE CABINETS
19. WORK BENCHES



UPPER 'TWEEN DECK

Figure 8.

One Kreonite sink in the darkroom is used for processing 4" x 5" black-and-white negatives in tempered tanks; a second is for tray processing of prints and serves as a backup for the Kreonite print processor. Also in the photography lab are a dry sink with a Polaroid MP-4 Copy Stand and lights, a Beseler Slide Duplicator, and a deep sink to accommodate the print processor.

In the core lab, a specially designed core photography table is used to photograph all the archive halves of a core at one time. A Polaroid MP-4 Copy Stand identical to the one in the photography lab is used for close-up photographs of core sections and samples. It accepts both black-and-white and color film.

Second Look Lab

The second look lab is located on the lower 'tween deck outside the core locker (Figure 9); scientists can use this lab to carry out further descriptive work after cores have been removed from the core lab and stored in the refrigerated locker. The lab is equipped with a table for core description, a binocular microscope, a hotplate for smear slides, and basic supplies. There is a computer terminal for data entry and comparison purposes.

Core Storage

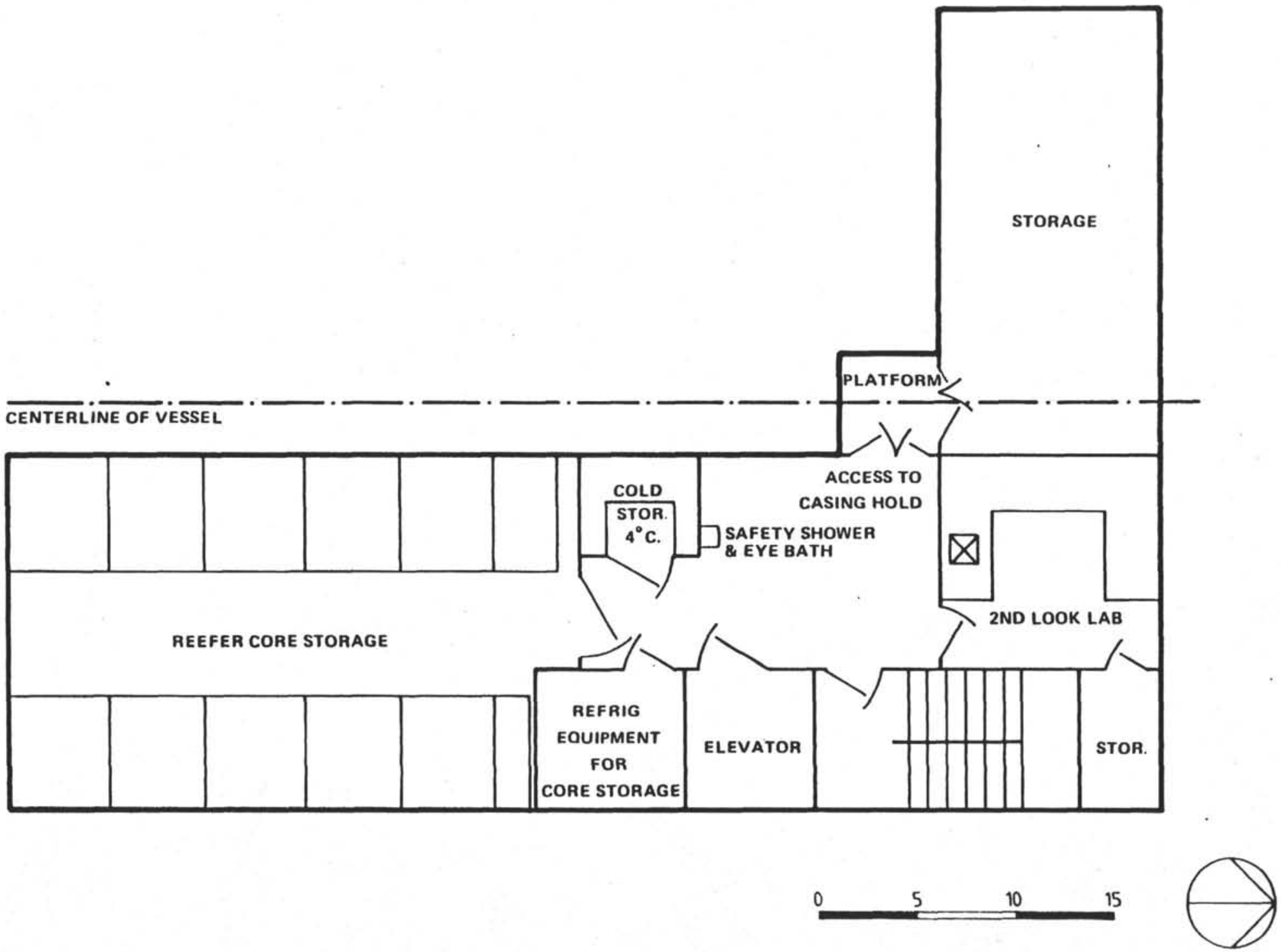
Refrigerated core storage facilities are located on two of the lab structure's lower levels (Figures 9 & 10). A total area of 931 sq ft can hold as many as 990 boxes of D-tubes, or about four legs worth of core sections. The lab stack's elevator allows technicians to bring core sections down to the core storage areas quickly and efficiently. On the hold deck (Figure 10), a 504 cu ft walk-in freezer holds frozen sediment samples. A separate refrigerator kept at $4^{\circ}C$ is used to store photographic supplies and chemicals.

Downhole Instrumentation Laboratory

The downhole instrumentation laboratory, located atop the bridge deck of the laboratory structure (Figure 11), houses equipment and work space for logging tasks. Lab space is divided into two sections: (1) a wet lab section for tool storage, cleaning and major repair of tools, and storage for ancillary equipment; and (2) the dry lab for computer and electronic equipment and repair facilities. A Masscomp computer data acquisition system in the dry lab is linked through a closed circuit to the main logging winch. Surface panels for different logging tools are also linked with data acquisition; graphics are provided by a Versatec plotter. Electronics repair and support are also housed within the dry lab.

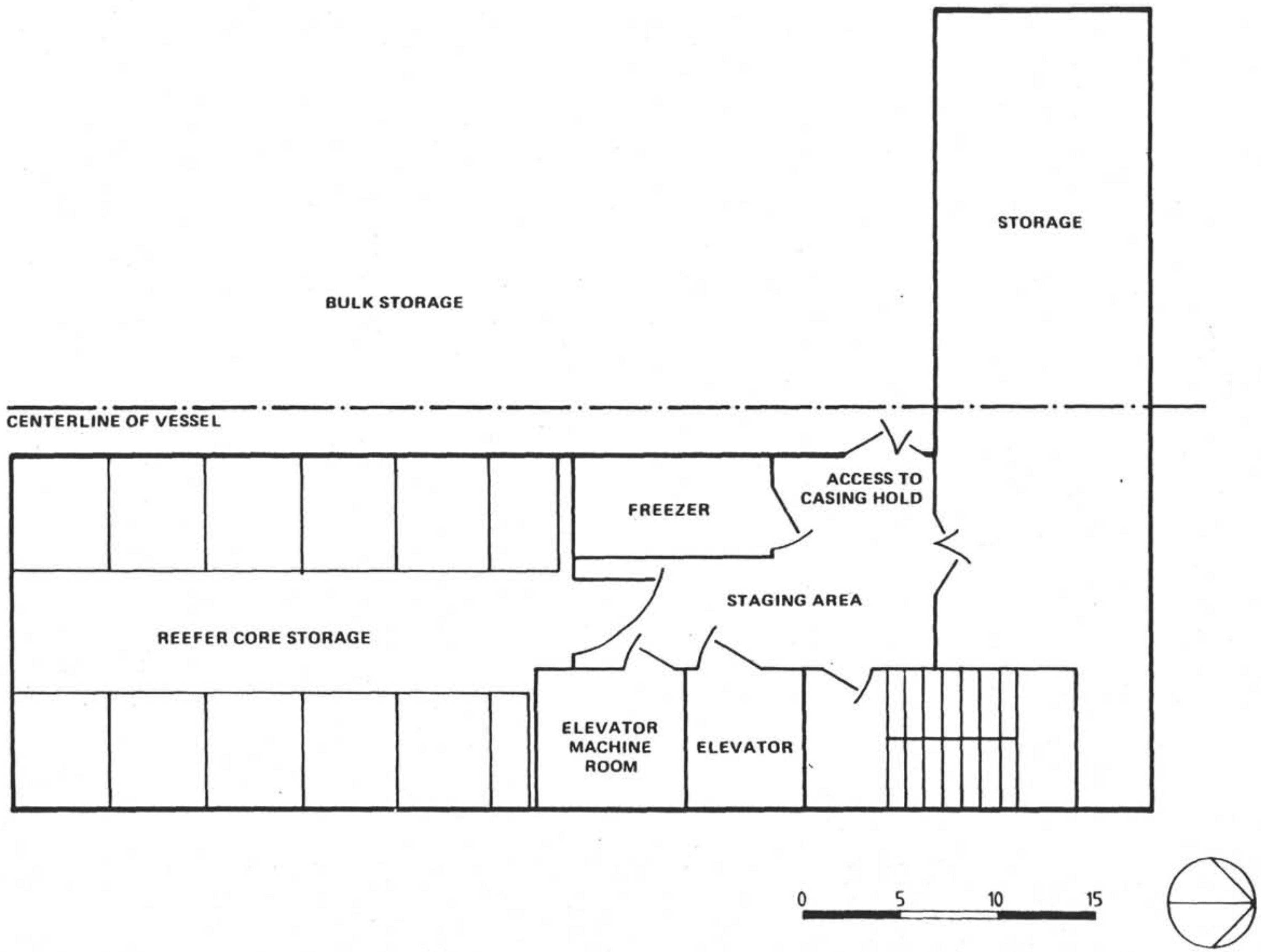
The following logging tools are available as part of the standard wireline logging package offered by Lamont-Doherty Geological Observatory (L-DGO) through a sub-contract to Schlumberger:

(1) Formation Density Logs (also called Gamma-Gamma) to establish bulk density of cored formations,



LOWER 'TWEEN DECK

Figure 9.



HOLD DECK

Figure 10.

CONTROL ROOM

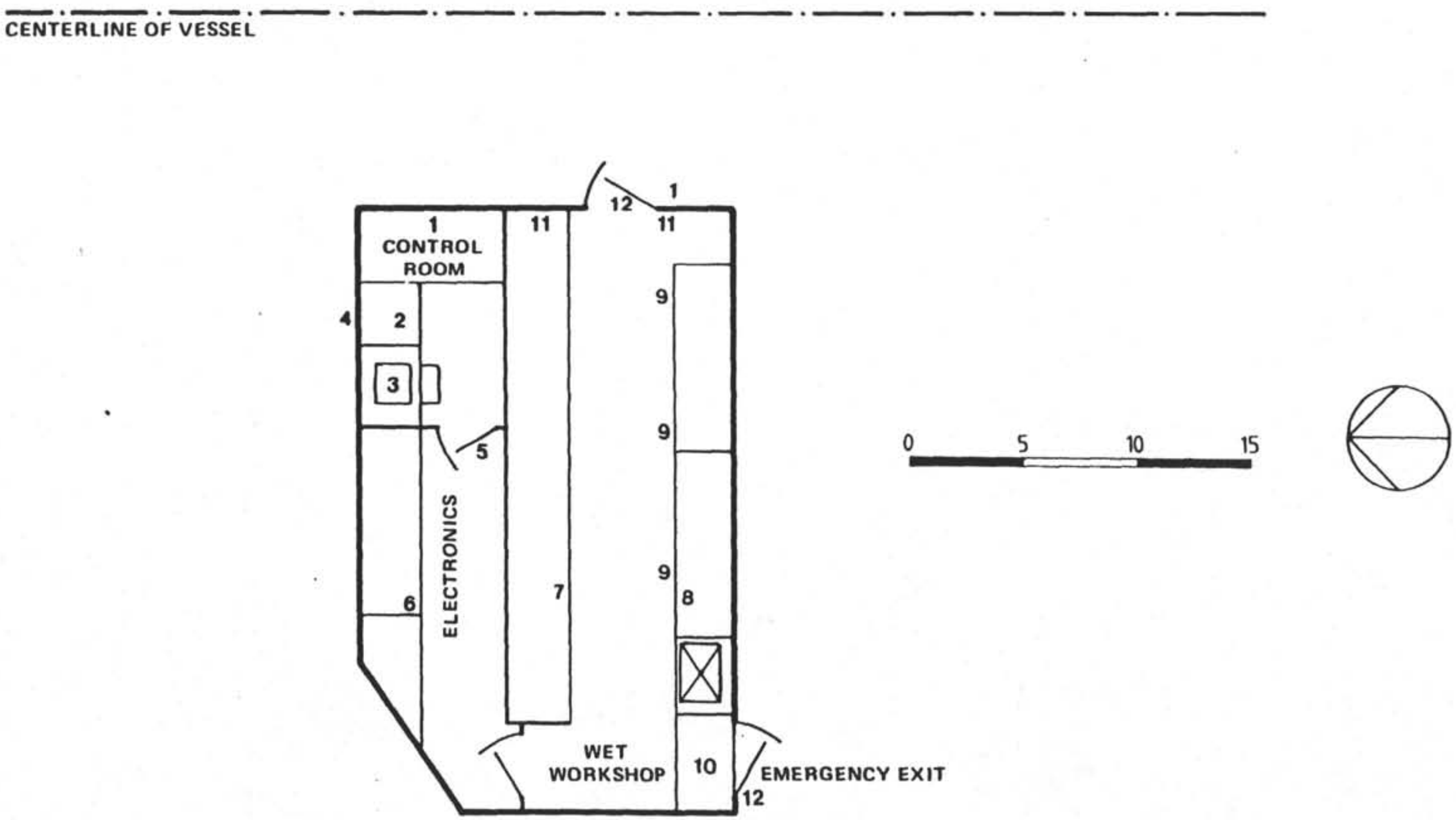
1. ELECTRONICS RACK
2. FOLD DOWN COUNTER
3. CONTROL DESK WITH COMPUTER & INTERCOM TO LOGGING WINCH OPERATION
4. OPERATION VIEWING PORT HOLE
5. AIRTIGHT DOOR

ELECTRONICS

6. WORKBENCH

WET WORKSHOP

7. HEAVY DUTY WOOD WORK BENCH DOWNHOLE TOOL RACKS BELOW
8. HEAVY DUTY WOOD WORKBENCH RE-ENTRY TOOL RACKS BELOW
9. HOOK-ON WORKBENCH EXTENSIONS
10. FOLD DOWN TABLE
11. MONORAIL ABOVE
12. WATERTIGHT DOOR



BRIDGE ROOF DOWNHOLE LOGGING

Figure 11.

(2) Natural Gamma Ray Logs to detect shale and clay beds, locate radioactive minerals, detect alteration in the ocean crust, and make depth correlations among other logs run,

(3) Neutron Porosity Logs to indicate the amount of hydrogen in the formation and thereby determine porosity,

(4) Temperature Logs to determine temperature of the borehole fluids versus depth,

(5) Caliper Logs to determine the diameter of the cored hole,

(6) Electric Resistivity Logs to determine formation resistivity,

(7) Spontaneous Potential (SP) Logs to detect shaly zones,

(8) Sonic Logs to measure the compressional velocity in formations over vertical differences of several meters and determine the elastic properties of the cored materials, and

(9) Sonic Waveform Logs to determine shear and Stoneley-wave velocities and to improve the accuracy of the compressional velocity measurements.

In addition to the standard suite of logging tools, L-DGO is developing the following tools specifically for use by ODP:

(10) Borehole Televiewer to detect and evaluate the dip and orientation of fractures and bedding in the wall of the borehole, and

(11) Multichannel Complete Waveform Sonic Log to determine shear wave, compressional wave, Stoneley wave and normal mode velocities, frequency, and amplitude, thereby allowing determination of the various elastic properties of the formation.

Additional tools will be developed at L-DGO, including a wireline packer pore-water sampling and permeability device, a dipmeter, special temperature probes, a magnetic gradiometer, and neutron activation and gamma-ray spectral logs for downhole geochemical analyses.

The ship's logging facilities include a rapid analysis combination of uphole recording, playback, and cross-correlation software designed for real-time assistance in geological interpretation while at the drill site.

<u>ODP Downhole Tools</u>

ODP is in charge of all downhole instrumentation other than that managed by L-DGO, such as equipment on the sandline, core line, hydraulic piston corer, and logging wireline not connected to the L-DGO computer. The ODP equipment consists of the following instruments:

(1) Core orientation multi-shot compass/camera: A non-magnetic pressure case housing an Eastman-Whipstock Magnetic Multishot Camera can be installed in the sinker bar assembly used to connect

the sandline to the Advanced Piston Corer core barrel. This core orientation system provides photo discs showing the magnetic reference azimuth for each piston core as well as a measurement of deviation from vertical and the azimuth direction of the nonverticality, that is, the angle of the hole at the specific location of the core in question and which way it is pointing.

(2) Pressure core barrel: Two complete pressure core barrels are on hand. DSDP operations have shown the system to be viable but susceptible to jamming in the hole and low core recovery. This system was used rarely during the DSDP cruises; on Leg 76 it recovered hydrate gas under pressures of 1500 to 4700 psi. It is capable of recovering cores up to 6.8 m long and 54 mm in diameter while maintaining in situ pressures up to 5000 psi. The pressure and temperature of the pressure chamber may be measured and fluids withdrawn through a sampling port. Solid material cannot be removed under pressure.

(3) Other engineering tools: A series of tools is used by the ODP Engineering and Operations Group to monitor and improve drilling capabilities on the ship. These tools are deployed when they can be fit into normal operations in order to increase the quantity and quality of baseline data. These data provide information on actual accelerations at the bit during coring or other selected operations, and on drill pipe stresses including binding, tension, and torque. The shipboard-mounted Ship Motion Data System, a vertically stabilized gyro sensor package, gives continuous data on roll, pitch, and heave of the ship; this information correlates with the downhole tools' data. Dedicated shipboard programs using these tools can impact scientific time allotments, but information gained is used to verify analytical computer model predictions of fatigue and stress and provides ODP with guidelines on safe drill string operating limits.

(4) In situ pore water sampler and pressure measurement instrument: The two battery-operated pore water samplers used on Glomar Challenger are available for use on ODP cruises. These are lowered downhole on the sandline to collect small volumes of pore water in teflon-lined receptacles. Pressure transducers can be plumbed into the pore-water sampler and a recording instrument used in place of the temperature recorder, but this modification must be assembled well in advance of anticipated use on a cruise. In addition, this equipment requires re-fitting to accommodate larger pore-water samples or for use in hot holes (>70°C).

(5) Temperature measurement tool (heat flow shoe): A self-contained temperature recording device has been developed for use with the hydraulic piston corer. The standard single cutter shoe/core catcher is replaced on data runs by a special two-piece assembly. Pressure-tight pockets in the wall of the shoe contain a small thermistor/electronics package and a battery. Temperature data are recorded (at preset time intervals) throughout the core run. Only about a five-minute delay is required for equilibration after actuation of the corer and before retrieval commences. On recovery, data may be read directly and plotted by computer.